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Beliefs and Attitudes of Primary School Mathematics Teachers Towards STEM Education

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Abstract

Background/purpose. Science, Technology, Engineering, and Mathematics (STEM) interdisciplinary education in schools may spark students' interest in learning the subjects and further help develop human capital and a STEM-educated workforce. However, many teachers are yet to be prepared to integrate STEM education into the school curriculum. Considering the significance of teachers' perspectives on STEM education, this study aimed to determine the correlation between primary school mathematics teachers' attitudes and beliefs about STEM education.

Materials/methods. Using simple random sampling, forty-nine primary school mathematics teachers were selected to participate in this quantitative research utilizing a questionnaire with a five-point Likert scale. The study objectives were addressed using descriptive analysis. Further, the Statistical Package of the Social Sciences (SPSS) was used to conduct Pearson's correlation and simple linear regression analyses.

Results. The study found that primary school mathematics teachers had moderate attitudes and beliefs toward STEM education. Additionally, a significant correlation existed between primary school mathematics teachers' beliefs and attitudes towards STEM education. A simple linear regression test confirmed that teachers' beliefs in STEM education influenced their attitudes towards STEM education with a value of adjusted R^2 = .860. Furthermore, the Multivariate Analysis of Variance (MANOVA) test results showed that participation in STEM Professional Development (PD) is a significant factor in mathematics teachers' beliefs and attitudes towards STEM education.

Conclusion. There is a need to provide quality and sustainable professional development programs to support teachers' knowledge in integrating STEM education in primary school curriculum.

1. Introduction

Educational systems must be transformed to compete globally. Raising the standard of Science, Technology, Engineering, and Mathematics (STEM) education could be one way of achieving this (Mustam & Adnan, 2019). According to Thibaut et al. (2017), every nation prioritizes preparing students to work in STEM fields to meet the demands of human society, economic change, and challenges of twenty-first-century rapid technologies. In order to increase the workforce and meet the needs of economic change, particularly in science and technology, students must be encouraged to pursue STEM fields at the primary school level (Hackman et al., 2021). Consequently, an early interest and involvement in STEM can attract students to these fields (Kaderavek et al., 2020; Yu et al., 2020). Furthermore, it will indirectly support student achievement in school and their decision to pursue a STEM career after finishing their studies (Arrington & Willox, 2021). According to Fitzallen (2015), mathematics should be given more weight when influencing educational reform involving STEM integration. Students will more frequently use their mathematics knowledge in the real world if they learn it through STEM integration (Milaturrahmah et al., 2017). Through exploring and discovering problem-based STEM learning activities, students act as problem solvers to work out authentic daily situations (Mutambara & Bayaga, 2021). According to Ajzen and Fishbein (1980), teachers' beliefs are personal opinions about what they believe to be true. Teacher beliefs are ideas and actions used in teaching (Gilakjani & Sabouri, 2017) and significantly influence their teaching practices (Schoen & LaVenia, 2019).

Furthermore, teacher attitudes are a significant challenge to successfully implementing integrated STEM teaching. A teacher's attitude involves cognitive, affective, and behavioral elements as well as the positive or negative evaluation of anything involving the person's environment or personal life (Aldahmash et al., 2019; Wahono & Chang, 2019). It also involves the teacher's curiosity about STEM education, their agreement to integrate STEM into their instruction, and what the teacher thinks about STEM education (Sujarwanto & Ibrahim, 2019). Many teachers have a negative attitude toward implementing STEM education, indirectly affecting students' views of STEM education (S. C. Lee et al., 2021). In the long term, this influences students' academic achievement (Aldahmash et al., 2019). It is important to note that teachers' positive attitudes toward STEM education can impact their classroom practices and play an essential role in their will to employ new approaches, techniques, and activities (Thibaut et al., 2017). These factors may influence the effectiveness of the implementation of STEM education in mathematics and science classrooms (Wei & Maat, 2020). Therefore, the attitudes and beliefs of primary school teachers are the most critical component in ensuring that STEM education objectives are achieved. Many primary school teachers lacking positive attitudes and beliefs toward STEM education may fail to effectively teach subjects integrating STEM (Dailey et al., 2018; Karen, 2019; Nesmith & Cooper, 2019).

School teachers must have authentic experience and profound knowledge to integrate STEM subjects. For example, primary school teachers should engage in classroom activities that expose them to related engineering knowledge and skills as well as its pedagogy (Porter et al., 2019). However, teachers may need more resources and development programs to teach STEM subjects and execute STEM-based education (Rich et al., 2020; Suebsing & Nuangchalerm, 2021). However, teachers' access to high-quality STEM professional development (STEM PD) is often limited (Costa et al., 2022). Investigating the attitudes and beliefs of STEM teachers can provide a solid foundation for creating high-quality professional development programs for STEM education (STEM PD) that can support integrated STEM teaching and learning in classrooms (Srikoom et al., 2017). Therefore, this study aimed to:

RO 1: determine primary school mathematics teachers' attitudes and beliefs about STEM education and the relationship between these variables.

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RO 2: investigate the extent teachers' beliefs and attitudes toward integrating STEM education influence their actual practice.

RO 3: examine the impact of STEM PD participation on teachers' beliefs and attitudes towards integrating STEM education.

2. Literature Review

Teacher beliefs refer to teachers' thoughts and interpretations about their work, encompassing their feelings, attitudes, experiences, and decisions (Sahin et al., 2002). Teacher beliefs are part of teacher competence (Minarni et al., 2018) and are likely to influence classroom practices (Schoen & LaVenia, 2019; Zikre & Eu, 2016), including planning, decision-making, and behavior (Erkmen, 2012). Mansour et al. (2024) emphasized that beliefs significantly influence teachers' effectiveness in integrating technology into STEM education and project-based learning (PBL). A person's experiences shape their beliefs, embedding them deeply into their lives. Conceptually, beliefs can be described as an individual's assessment of the truth or falsity of an action or statement (Pajares, 1992). According to Levin (2014), teachers simultaneously hold various types of beliefs, including beliefs about knowledge (epistemology), their students, themselves, the content of their lessons, teaching methods, as well as moral, ethical, and social dilemmas that influence classroom teaching (Levin, 2014). Wilson and Cooney (2002) emphasize that teachers' beliefs play a major role in shaping what is taught, how it is taught, and what students learn in the classroom.

According to Omolara and Adebukola (2015), attitudes are patterns of thought that influence how a person thinks and acts, either positively or negatively. Attitude is defined as a learned tendency to consistently respond to objects in a preferred or disliked manner (Fishbein & Ajzen, 2011). Individuals typically choose behaviors that produce their desired effects and, conversely, develop negative attitudes toward behaviors that fail to achieve the desired outcomes (Hassan et al., 2018). Therefore, attitudes are considered a key determinant of a person's willingness to make a change. Many factors influence individual attitudes and behavior, each of which plays an important role in shaping the way an individual thinks, feels, and acts. Azwar (2007) identified five major factors that contribute to attitude formation: personal experiences that leave a lasting impression, environmental influences from significant individuals or groups, cultural influences that shape societal norms and values, exposure to media that affects perceptions, and religious teachings along with moral concepts that guide ethical behavior. Furthermore, the three dimensions of attitude—cognitive, affective, and behavioral—are closely related, collectively influencing a person's decisions and actions. Fishbein and Ajzen (2011) highlight the dynamic interaction between cognitive content, affective components, and behavioral elements, emphasizing how these factors work together to develop an individual's habits and skills over time. Understanding this interconnectedness is essential to understanding how attitudes develop and guide human behavior.

There is a relationship between teachers' belief systems and their classroom practices (Calderhead, 1996; Pajares, 1992; Sahin et al., 2002; Schoen & LaVenia, 2019). Calderhead (1996) proposed that teacher beliefs explain the relationship between teachers' knowledge, beliefs, and teaching practices. According to Calderhead (1996), teacher belief systems encompass beliefs about students and learning, beliefs about teaching, beliefs about the subject, beliefs about learning to teach through professional development programs, and beliefs about the self and the role of teaching. This aligns with the teacher change model developed by Guskey (1986), which asserts that teachers' internal efficacy increases alongside their beliefs in the importance of recommended teaching practices (acquired through professional development programs) when they use new teaching methods and implement them effectively in their classrooms. Guskey (1986) also argued that professional development programs often fail to bring about changes in attitudes and beliefs. However, significant changes are frequently reported when teachers observe the positive results of using new teaching methods and experience success in improving student achievement (Pajares, 1992).

3. Methodology

This study employed a quantitative methodology involving 49 primary school mathematics teachers from various states across Malaysia in 2022. The participants completed the questionnaire through an online Google Form. According to Andrade (2020) and Schwarzkopf and Huang (2024), a small sample size of 49 participants is acceptable if the study design and statistical analysis are properly executed, ensuring the validity and reliability of the results. Research by Etz and Arroyo (2015) and Cao et al. (2024) indicates that while a small sample size may not be ideal, it can still yield meaningful and useful results. The study utilized simple random sampling to select these participants. The demographics of the study participants are presented in Table 1.

Table 1. Background Demographics of the Respondents.

Demographic characteristics	Frequency	Percentage %
Gender		
Male	21	42.9
Female	28	57.1
Age		
20–30 years old	3	6.1
31–45 years old	42	85.7
46 years old and above	4	8.2
Teaching option		
Mathematics	36	73.5
Science	2	4.1
Others	11	22.4
Participated in STEM PD		
Yes	23	46.9
No	26	53.1

We developed an instrument that adapted items from A. R. Lee (2017) and Yunus (2015). To ensure the validity of the questionnaire in terms of content and language, it was reviewed by three experts: a linguist who is an excellent language teacher, a lecturer at the Teacher Education Institute (IPG) specializing in STEM, and the head of a mathematics department. These experts provided feedback and suggestions for improvement before the questionnaire was distributed to the study participants. The five-point Likert scale utilized 'Strongly Disagree = 1', 'Disagree = 2', 'Not Sure = 3', 'Agree = 4' and 'Strongly Agree = 5' categories. The questionnaire consisted of three main sections: Section A for demographic data, Section B for items related to teachers' beliefs, and Section C for teachers' attitudes toward integrating STEM. Construct reliability was assessed using Cronbach's alpha. The results revealed that the Beliefs section of the questionnaire, with ten items ($\alpha = .79$), and the Attitudes section of the questionnaire, with ten items ($\alpha = .74$), were reliable based on Hair et al. (2010). Sample items from the questionnaire are listed in Table 2.

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Table 2. Sample Questionnaire Items.

Section B (Beliefs)	Section C (Attitudes)
B02: I am confident I have the necessary skills to teach science/math.	C03: I always discuss with other teachers to overcome weaknesses in the teaching and learning process of STEM-related subjects.
B05: I believe that STEM education makes student learning more relevant.	C05: I always make innovations in the teaching and learning processes of STEM-related subjects according to the appropriateness of the topic.
B08: STEM education effectively trains students to think outside the box.	C09: I always relate my lesson to the real-world context.

After collecting data, we screened and cleaned the missing values from the questionnaire using the Statistical Package for the Social Science (SPSS) version 23. Before analyzing the data in SPSS, we checked all assumptions before performing the inferential statistics for simple linear regression and correlation tests. The first assumption involved normality tests. For respondents less than 50 (n = 49), the Shapiro–Wilk test was chosen to measure the normality of the distribution. According to Ahad et al. (2011), the Shapiro–Wilk test rejects the null hypothesis of normality at the most petite sample sizes compared to the other tests at all Skewness and Kurtosis levels, making it the most sensitive normality test. The Shapiro–Wilk test showed a non-significant value where the value obtained was more significant than p = .05 for teachers' beliefs (p = .36) and teachers' attitudes (p = .22) towards STEM education. Therefore, parametric testing was carried out as the data for this study were proven to be normally distributed considering both variables, and the significant value obtained by the test exceeded 0.05. Other assumptions that needed to be met were linearity and homoscedasticity, which were tested by referring to a scatterplot. The scatter plot showed that the variables were proven to be linear. As shown in Figure 1, the points also seemed randomly scattered, without having any relationships. This showed that the data met the assumptions of linearity and homoscedasticity.

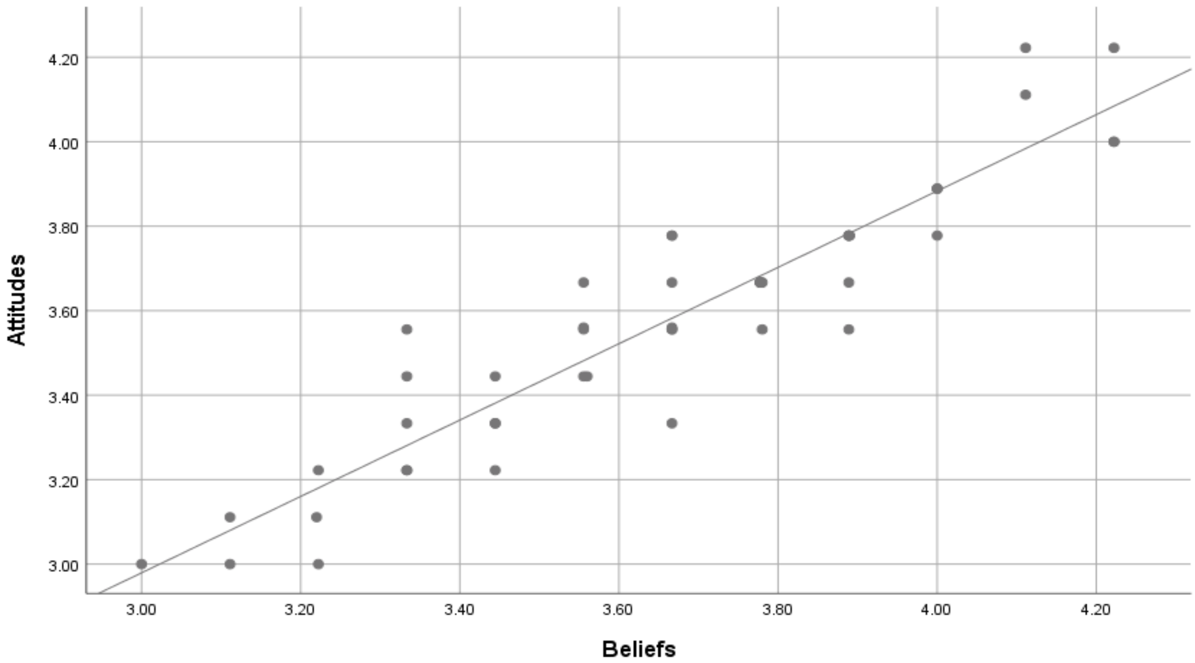

Figure 1. Scatter Plot Attitudes and Beliefs

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4. Results

4. 1. Teachers' Beliefs and Attitudes Towards STEM Education

The degree of beliefs and attitudes towards STEM education among primary school mathematics teachers is the overall mean for the belief and attitude construct. According to Idris (2008), a low category occurs when the overall mean is between 1.00 and 2.33, and a medium level has a mean between 2.34 and 3.67. In contrast, a high level is indicated by an overall mean of 3.68–5.00. As shown in Table 3, the level of belief of primary school mathematics teachers towards STEM education was moderate, with a mean value of 3.66. Meanwhile, the overall mean value obtained for the attitude construct was 3.58. This shows that the attitudes of primary school mathematics teachers were moderate towards STEM education. Additionally, the standard deviation values obtained by both constructs were close to zero, implying that the data were scattered around the mean.

Table 3. Descriptive Analysis Results

Constructs	Mean	St. Dev
Beliefs	3.66	0.31
Attitudes	3.58	0.30

4. 2. The Relationship Between Teacher Beliefs and Attitudes

Pajares (1992) and Santos and Miguel (2019), who discuss the relationship between teachers' beliefs and attitudes, claim that beliefs will develop a person's attitudes and actions and directly affect how a teacher teaches the subject matter and the instructional strategies used in the classroom. Some elements of belief, such as negative beliefs, contribute to forming negative attitudes in school.

To answer the second research objective, Pearson's correlation analysis was used to determine if there was any relationship between the beliefs and attitudes of primary school mathematics teachers towards STEM education and their attitudes towards STEM education. A hypothesis was constructed and tested using this Pearson correlation analysis test. The results of the Pearson correlation analysis are shown in Table 4. A Pearson correlation coefficient was computed to assess the linear relationship between teachers' beliefs and attitudes, which showed that the two variables were highly correlated ($r = .93$, $p < .001$).

Table 4. Pearson Correlation Test of Teacher Beliefs and Attitudes toward STEM.

	Beliefs	
Attitudes	Pearson correlation	0.93
	Sig. Value	p <.001
	N	49

4. 3. The Impact of Teacher Beliefs on their Attitudes

After discovering a positive relationship between these two constructs, a simple linear regression test was conducted to investigate the impact of beliefs on the attitudes of primary school mathematics teachers towards STEM education. The results of this analysis are shown in Table 5.

Table 5. Simple Linear Regression of Teacher Beliefs on their Attitudes.

Model	R	R-square	Adjusted R-square	Std. error in the estimate
1	.93[a]	.86	.86	.11

Predictors (Constant): Beliefs; Dependent Variable: Attitudes

For a sample of less than 100 (N = 49), the adjusted R-square value should be reported instead of the R-square value, as Pallant (2010) suggests. The adjusted R-square value obtained was 0.86 based on the regression test results. The fit was better when the R-square value was close to one. In conclusion, the data show that 86% (0.860 x 100) of the attitude variation was due to belief changes. The test found that teachers' beliefs in STEM education contributed to the strong influence of their attitudes towards STEM education by 86% of the variance. A significant regression equation was found F(1,47) = 296.632, p <.001, with an R2 of .86. Participants predicted attitudes are equal to Y = 0.27 + 0.90X.

4. 4. The Impact of STEM PD on Beliefs and Attitudes

To determine if teachers' participation in STEM PD affected their beliefs and attitudes, the researcher conducted a Multivariate Analysis of Variance (MANOVA). The MANOVA test was conducted to test the null hypothesis (Table 6), which stated that there was no significant difference in the beliefs and attitudes of primary school mathematics teachers based on their participation in a STEM PD program.

Table 6. Box's M Test.

Box's M	F	df1	df2	Sig.
1.61	0.51	3	818359.68	0.67

The Box's M test is a prerequisite that must be conducted before performing the MANOVA test to determine the homogeneity of variance among the dependent variables and the independent variables (Pallant, 2010). Based on the results in Table 6, which shows that the test result was insignificant (F = 0.51, p = .67), it was evident that the dependent variable's covariance was consistent across independent variables.

Table 7. MANOVA Analysis of Differences in Beliefs and Attitudes based on Participation in STEM PD

Effect	Pillai's trace value	F	Hypothesis df	Error df	Sig.
STEM PD	0.52	24.67	2	46	<.001

Pillai's trace test statistic provided more reliable findings in the event of homogeneous variance. The results of Pillai's trace analysis are reported in Table 7. The existence of a significant main effect of the independent variable STEM PD, $F(2,46) = 24.665$, $p < .001$ on both dependent variables taken as a whole was shown with the results presented in Table 8.

Table 8. The Impact of Involvement in STEM PD on the Level of Teacher Beliefs and Attitudes

IV	DV	Sum of Square	df	Mean Square	F	Sig.
STEM PD	Beliefs	2.28	1	2.28	47.05	<.001
	Attitudes	1.59	1	1.60	27.65	<.001

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A separate MANOVA test was conducted, which revealed a significant difference between the two categories, namely, STEM PD involvement on the level of belief, $F(1,47) = 47.05$, $p < .001$ and the level of attitude, $F(1,47) = 27.66$, $p < .001$. This analysis report demonstrated that participation in STEM PD significantly influenced mathematics teachers' beliefs and attitudes toward STEM education.

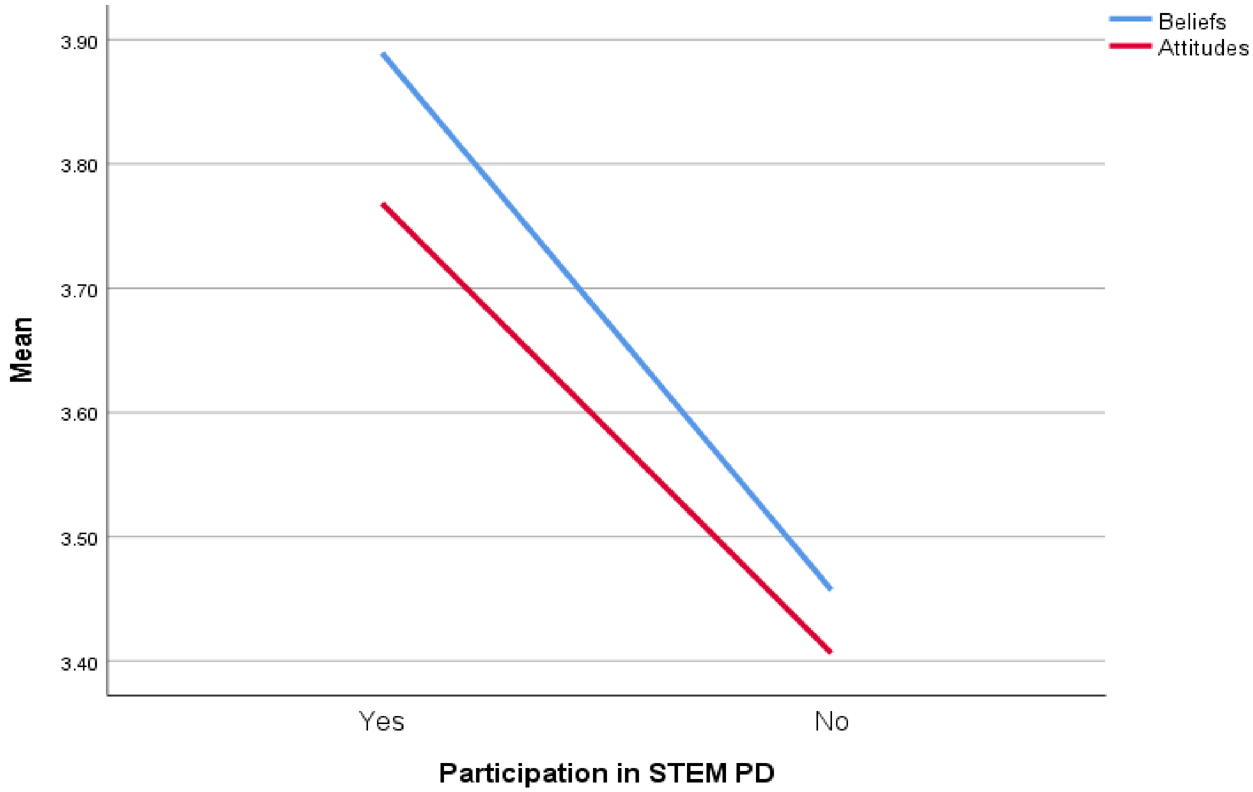

Figure 2. Mean Comparison Graph

Furthermore, referring to the mean value for the group of teachers who had participated in STEM PD and the group of teachers who had never attended STEM PD, it was found that the group of teachers who had participated in STEM PD had a higher level of beliefs and attitudes towards STEM education. This can be explained further by referring to the graph in Figure 2.

5. Discussion

The main objective of this study was to determine primary school mathematics teachers' beliefs and attitudes toward the implementation of STEM education. This is important because the relationship between these two elements impacts teachers' selection and performance of strategies to teach mathematics, affecting student achievement. Thurm and Barzel (2020) state that priority should be given to changes and expansion of teachers' attitudes and beliefs. Developing teachers' attitudes and beliefs can ensure teachers are ready to apply all the necessary skills and progress in their instruction (Er & Kim, 2017). Developing teachers' beliefs and attitudes is crucial to help them employ high-quality teaching practices (Levin, 2014). The current study showed that primary school mathematics teachers' beliefs and attitudes towards STEM education remain moderate. In addition, there is a strong relationship between the beliefs and attitudes of primary school mathematics teachers towards teaching STEM education. In comparison, teachers' attitudes towards STEM education are more strongly influenced by their beliefs.

A study by Alkhateeb (2018) found that most mathematics teachers still have conventional perceptions and beliefs regarding STEM education, and thus they employ poor mathematics teaching skills and reject integrating mathematics with other STEM subjects. In addition, they also need a more

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robust perception of providing a class environment that can make their students more active. Next, a study by Mustam and Adnan (2019) found that mathematics teachers' belief in implementing STEM education needs to be stronger. Their study also showed that teachers considered that the content of STEM education needed to be revised and be more accessible to be applied in the classroom. A study conducted with teachers who teach STEM by Al Salami et al. (2017) found that mathematics teachers had lower attitudes toward STEM education than teachers with expertise and knowledge in engineering, technology, and science. In addition, the mathematics teachers in the study showed a highly negative attitude toward changing their attitudes compared to other groups of teachers. This may be due to the attitude of mathematics teachers, who are more axiomatically oriented, compared to science subject teachers, who are more empirically oriented (Thibaut et al., 2017). In mathematics education, the axiomatic attitude refers to the belief that mathematics is a logical and self-evident set of rules.

The findings of this study also revealed a significant difference between teachers who have participated in a STEM PD program and those who have never directly followed such a program. Teachers who participated in a STEM PD program had more positive beliefs and attitudes than teachers who had never attended such a program. This shows that a STEM PD program impacts teachers' beliefs and attitudes toward implementing STEM education. Teachers need to be prepared with the knowledge and teaching skills of STEM education because it indirectly shapes their instruction. Primary school teachers' participation in STEM PD programs may help them develop their understanding, attitudes, and beliefs toward integrating STEM into their lessons (DeCoito & Myszkal, 2018; Hamilton et al., 2021; S. C. Lee et al., 2021; Porter et al., 2019). Through diverse STEM learning methodologies, STEM PD can also enhance teachers' beliefs and attitudes toward creating engaging STEM classes for primary school pupils (Havice et al., 2018; Turner et al., 2021). It has also been demonstrated that the effectiveness of a STEM PD program may influence how primary school teachers see STEM concepts and activities (Hamilton et al., 2021; Pleasants et al., 2020; Suebsing & Nuangchalerm, 2021). Participating in a STEM PD program inspires primary school teachers to think creatively when planning their classes. It assists them in cultivating a positive outlook to produce high-quality STEM lessons (Dailey et al., 2018).

Teachers' attitudes and beliefs strongly influence their instructional practices. When teachers hold positive attitudes and strong beliefs about the value and effectiveness of STEM education, they are more likely to allocate sufficient time, resources, and efforts to integrate STEM subjects effectively. STEM education can be challenging for teachers, particularly if they have limited content knowledge or need teaching experience. By addressing teachers' attitudes and beliefs, professional development programs can enhance their confidence in teaching STEM. When teachers feel competent in their ability to deliver high-quality STEM instruction, they are more likely to take risks, explore innovative teaching methods, and adapt to the evolving needs of their students. A teacher's beliefs are not based on theory alone but develop over experiences (Mansour, 2024). Thus, the teachers' experiences will assist them in developing a positive attitude toward integrated STEM education. Quillen (2004) states that belief systems are dynamic, consist of active mental structures, and are sensitive to changing experiences. Therefore, teachers' experiences in strengthening professional development programs can help develop their beliefs. This is because changes in this belief system will occur if old beliefs no longer influence their teaching practices (Quillen, 2004). Therefore, the learning process of mathematics teachers in professional development programs, for example, can build experience, help develop teachers' beliefs, and further build a positive attitude towards STEM education.

The findings of this study highlight the importance of designing effective STEM PD programs for primary school mathematics teachers. Improving teachers' attitudes and beliefs about STEM is crucial for successfully integrating STEM education into the classroom. To achieve this, policymakers and educators should develop PD programs that include hands-on STEM activities, collaborative learning, and real-world applications. These components can boost teachers' confidence and skills while making the training more engaging and relevant. Regular feedback and ongoing support should also be part of these programs to address teachers' needs and encourage professional growth. By focusing on these aspects, STEM PD programs can enhance the quality of STEM education in schools and inspire both teachers and students.

6. Conclusion and Implications

The findings of the current study call for authorities to make a sustained effort to influence teachers' beliefs and attitudes toward STEM education. The development of strong, positive beliefs and attitudes can lead to teachers who are qualified to teach STEM subjects and are equipped to handle any obstacles that may arise in the future. This is essential because effective teachers with positive beliefs and attitudes towards STEM education can influence the selection of teaching strategies and approaches used in the classroom and subsequently influence student interest and engagement. Mathematics teachers with moderate attitudes and beliefs in implementing STEM education can significantly impact the quality of STEM in schools. While some teachers may already possess a positive mindset and belief in the effectiveness of STEM integration, others may have reservations or uncertainties. However, participating in professional development programs can positively change teachers' beliefs and attitudes, ultimately enhancing the quality and future development of STEM education.

STEM PD programs can significantly impact teachers' attitudes and beliefs, positively changing their instructional practices and effectiveness in teaching STEM subjects. STEM PD programs provide teachers with new knowledge, skills, and resources to teach STEM subjects effectively. Teachers' self-efficacy improves as they gain confidence in teaching STEM. They develop a belief in their capacity to successfully engage students in STEM learning, resulting in increased motivation and enthusiasm for teaching these subjects. The positive impact of teachers' improved beliefs and attitudes towards STEM education extends beyond their classrooms. When teachers embrace and champion STEM integration, it will likely create a ripple effect throughout the school and beyond and make teachers influential advocates of integrated STEM education by inspiring their colleagues to explore and adopt innovative approaches in their teaching. This collective shift in attitudes and beliefs may lead to a school-wide culture that values and supports STEM education, ultimately benefiting all students and shaping the future of STEM education, which can, in turn, create a culture of innovation, collaboration, and student engagement that prepares students for the challenges and opportunities of the future.

Many countries have implemented STEM PD programs to meet the needs of teachers and equip them with the ability to implement new teaching approaches through STEM integration (Yamkasikorn, 2021). However, the expected quality of STEM teachers is yet to be achieved due to a lack of transfer between lessons acquired by teachers (Du et al., 2019; Margot & Kettler, 2019). As suggested by Havice et al. (2018), conducting more research to explore the influence of andragogy in learning the concept of STEM integration. Several studies have concentrated on the professional development of teachers in STEM education. Still, many do not consider external elements that may interact to effect changes in the activity system and teacher acceptability (Karen, 2019).

The small sample size of the current study may have limited the depth and generalizability of the findings. Future research should consider incorporating multiple data sources and methods to address this limitation. Combining questionnaires with qualitative approaches, such as interviews, focus groups, or observations, can provide a deeper and more comprehensive understanding of teachers' attitudes and beliefs. Further research can be done to explore other factors that influence mathematics teachers' beliefs and attitudes toward STEM education. Efforts to deepen our understanding of these factors may help the authorities design appropriate and quality professional development programs to support effective STEM education.

Declarations

Author Contributions. A.G.A: Literature review, conceptualization, investigation, data collection, analysis, software use, resources, and manuscript preparation. R. R.: Methodology, validation, resources, formal analysis, supervision, and writing—review and editing. M. S.M.: validation, supervision, review and editing. All authors have read and approved the published version of the article.

Conflicts of Interest. The authors declare no conflict of interest.

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Ethical Approval. This study was conducted in accordance with ethical guidelines.

Data Availability Statement. The data supporting this study are available from the corresponding author upon reasonable request.

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